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Preschool Phonological Representations and Development of Reading Skills

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Individual differences in the quality of phonological representations of kindergarten children may be predictive of Grade 1 phonological awareness and reading development. Three longitudinal studies are presented that attempt to measure variance in the quality of the phonological structures within lexical items using three tasks: nonword repetition, cued word fluency, and a gated auditory word recognition task. Nonword repetition was a consistent predictor of later phonological awareness, even after current phonological awareness and vocabulary knowledge were taken into account. The results of the three studies provide inconclusive support for the theory that individual differences in the quality of phonological representations play an important role in the development of explicit phonological awareness and reading acquisition. An important finding of the third study is that caution needs to be maintained in measuring skills in preschoolers as stability of results can be an issue when interpreting the relations between variables. However, the present studies do confirm that individual differences in vocabulary, nonword repetition, and phonological awareness are important factors in predicting the development of reading related skills.

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One underlying deficit found in the majority of children with dyslexia is an impairment in phonemic awareness (Oakhill & Kyle, 1999; Stahl & Murray, 1994). There is much evidence to show that phonological awareness (PA) is causally related to the acquisition of reading skill (see Stanovich, 1992). However, there is also research to show that learning to read is the most effective way to become phonemically aware (Johnston, Anderson, & Holligan, 1996). Preschool children generally have no awareness of the phonemic nature of spoken language, and their first contact with formal reading instruction acts as a powerful trigger for development of phonemic awareness (Hatcher, Hulme, & Ellis, 1994; Wesseling & Reitsma, 1998).

The reciprocal relationship between phonemic awareness and reading makes it difficult to utilize phonemic awareness tasks in kindergarten as a means of predicting potential reading difficulties in grade school. Therefore, the question arises: Is it possible, in the absence of reading ability and letter knowledge, to measure the potential to become phonemically aware? It has been hypothesized that an important prerequisite for phonemic awareness is the quality of phonological representations within the lexicon; that is, the amount and extent of phonological information used to define lexical items (vocabulary) (Elbro, Nielsen, & Petersen, 1994; Fowler, 1991). The theoretical role of the quality of phonological representations for PA and reading acquisition is still largely untested but has in very recent years gained popularity amongst reading researchers (Elbro, Nielsen, & Petersen, 1994; Fowler, 1991). The central issue in the current article is the relationship of the quality of phonological representations measured in kindergarten to individual differences of Grade 1 PA and reading acquisition.

The quality of phonological representations pertains to differences in the amount of phonological information used to represent items in the lexicon. Fowler (1991) suggests that infants' words are initially represented as unanalyzable wholes; as new words are learned, existing lexical items must be refined into a more segmented form in order to ensure that sufficient distinguishing features are available for the purposes of accurate aural recognition. Fowler (1991) argues that individual differences in lexical segmentation can readily account for a number of reported deficiencies in poor readers, including verbal short-term memory, nonword repetition, and perceptual deficits of verbal stimuli.

Although the segmentation theory of Fowler (1991) accounts quite well for the development of PA, one difficulty is

that differentiation of the lexicon is driven by vocabulary expansion. If the purpose of differentiation is to accommodate similar sounding words, then one could ask the question: "Why do lexically unique words also need to be refined to a phonological level?" Lexically unique words could remain represented as indivisible gestalts without hampering spoken word recognition. The distinctness theory (Elbro, Nielsen, & Petersen, 1994) avoids this difficulty by removing the requirement of vocabulary as the motor that drives the process of building an efficient lexicon. Instead, individuals "pack" vocabulary items with differing levels of (phonological) information to aid spoken word recognition. For a person listening to a sentence, a major difficulty in recognition is the variability of speech input due to environmental noise and differences in pronunciation. For example, the /d/ in the word *hand* seems to disappear if *hand* is followed by the word *me*, as in "hand me a hammer" (Lahiri & Marslen-Wilson, 1991). The skilled listener must be able to abstract away from the surface details but ensure that lexical representations remain distinct enough to keep them separate from other lexical items.

Elbro (1996) suggests that children who develop reading problems have less access to the most distinct variants of lexical representations. Distinctness of a lexical representation is the degree to which lexical items differentiate themselves from lexical neighbors. A lexical representation is distinct when it has many features that serve to distinguish it from other lexical items. The distinctness theory differs from the segmentation hypothesis because the highest level of distinction does not necessarily need to be at the phoneme level but also could incorporate allophones; for example *tomato* may be pronounced /*tɘuma . . . tɘu*/ or /*tɘumeitɘu*/.

Elbro (1996) hypothesizes that less distinct words are harder to segment and manipulate. Furthermore, the extraction of grapheme to phoneme correspondences may directly relate to the distinctness or quality of the lexical representations. A recent Danish longitudinal study (Elbro, Borstrøm, & Petersen, 1998) supports this hypothesis using a task in which a child is asked to identify and correct mispronunciations of complex words made by a puppet (the experimenter acted as a ventriloquist). Three measures in kindergarten appeared to contribute independently to the prediction of dyslexia: letter naming, phoneme identification, and distinctness of phonological representations.

The distinctness of phonological representations does not appear to be related to the size of the vocabulary store. The results reported by Elbro, Borstrøm, and Petersen (1998) indicate

that neither receptive nor productive vocabulary contributed independently to the prediction of PA in second grade. Rather, the quality of the phonological structure of lexical representations is crucial both for PA and learning to read. From this point on, when referring to individual differences in the phonological structure of lexical items, the term Quality of Phonological Representations (QPR) will be used.

MEASURING THE QUALITY OF PHONOLOGICAL REPRESENTATIONS

Generally, preschoolers are not literate and have little or no awareness of phonemes; therefore, PA tasks are not appropriate to predict the potential of prereaders to develop reading difficulties in grade school. However, there may be tasks less dependent on literacy knowledge that measure the potential to become phonemically aware. One method may be to determine the extent of lexical differentiation. There are some empirical findings showing that it is possible to measure the process of lexical differentiation. Metsala (1997) presented evidence, using the gating paradigm, to argue that the lexicon of young children and poor readers is more holistic than the lexicon of older children and adults. The gating paradigm is a task of spoken word recognition that gauges the amount of auditory stimuli a listener requires for spoken word identification. Young children have a smaller vocabulary (lexicon) than older children and adults, so one could predict that younger children would find it easier to recognize words in a gating task due to fact that they have less items in their lexicon to search. However, the consistent finding is that older children and adults require less aural input for correct identification of words than young children. This finding provides evidence that gating tasks indicate the level of lexical differentiation (Metsala, 1997).

In the gating paradigm, the point where the partially presented word has no alternative word candidates is termed the *point of uniqueness.* The differences in lexical differentiation are more discernible when using words from sparse neighborhoods because point of uniqueness is arrived at sooner. For example, a listener is auditorily presented with the onset and the vowel of the two words "tulp" and "bord." In Dutch, the word "tulp" (*tulip*) has few lexical neighbors, whereas "bord" (*plate*) has many. The point of uniqueness in "tulp" is arrived after hearing /tu/; the point of uniqueness in "bord" is at the very end.

A study by Metsala (1997) showed that the gating performance of a seven-year-old child could predict concurrent reading ability. Words from sparse lexical neighborhoods were good predictors of reading ability (increase in $R^2 = 0.11$), even after the variance attributable to age, vocabulary, and phonological awareness were accounted for (total $R^2 = 0.67$).

There may be a number of other tasks, relatively unconfounded by current letter-sound knowledge, for measuring differentiation of the lexicon. One task of QPR could be *cued word fluency* in which the subject is provided with the onset of a word and asked to produce as many words in a short span of time that begin with the onset. The ease with which items are extracted from the lexicon indicates if lexical items can be accessed using partial phonological information.

Another task that may be suitable is *nonword repetition* (Fowler, 1991). Nonwords are, in essence, just like real words that have not yet been learned. One characteristic of a well-specified and distinct lexical system is the ability to assimilate new and novel words. In order to do this, the listener must have the required skills: accurate encoding, retention, and articulation ability. The nonword repetition task was first used by Snowling (1981), who found that children with poor reading ability were worse at repeating nonwords than reading matched younger children. Performance differences on a nonword repetition test are probably related to individual differences in the quality of speech encoding, storage, and articulation, and, therefore, also to the construction of stable phonological specifications in long-term memory during vocabulary acquisition (Gathercole, 1995). Nonword repetition should be related to vocabulary and this has been confirmed in empirical research. For example, Gathercole and Baddeley (1997) reported a mean correlation coefficient of 0.49 between nonword repetition and scores on standardized vocabulary tests for nine studies using this nonword repetition technique with children aged 4 and 6 years.

In total, three studies are presented. First, an initial small-scale study is reported that tests the suitability of measures of QPR. The second study is a larger scale replication of the initial study. Finally, in a third study, we examine the stability of various linguistic measures and the QPR measures over a period of two and a half years from early kindergarten until Grade 1. It is hypothesized that kindergarten children are likely to exhibit greater variation in cognitive skills than children attending grade school. This variation could manifest itself in less

representative and stable measures of QPR, and other language related abilities in kindergarten children.

STUDY 1

In the first study, we tested the suitability of three measures of the quality of phonological representations with a group of second year kindergarten children. There are three main aims for this study. The first is to examine the independence of the three chosen measures from both PA and letter-sound knowledge. The second aim is to examine if the three QPR task administered in kindergarten are unique predictors of PA and reading development in Grade 1; and the third is to ascertain the extent to which variance in Grade 1 reading ability can be predicted from kindergarten measures in general.

METHOD

Participants. Twenty-nine kindergarten children (17 boys and 12 girls) with a mean age of 6 years and 1 months (SD = 4 months) participated. The study was conducted three months before the end of the second kindergarten year. The children came from four different kindergarten classes in one school. Each class had a mixture of first year and second year kindergarten children; however, only second year kindergarten children participated. In the Netherlands, no instruction in reading related skills is given during kindergarten. Thirty two percent of the children came from Dutch families; the remainder came from Turkish, Moroccan, or Surinam families (68 percent). Only those children that spoke Dutch as their first language participated.

MATERIALS AND PROCEDURE

Tests in Kindergarten. Eight tests were first administered to the children in kindergarten. The tests were administered in two sessions that took approximately 25 minutes each to complete. In the first session, the letter sound correspondences, visual word identification, phonemic awareness, nonword repetition, and cued word fluency tests were done. In the second session, the gating and vocabulary were administered.

Letter Sound Correspondences. Twenty-seven different lower case graphemes used in Dutch were presented on a single page. The children were asked to provide the letter sounds without a time limit.

Visual Word Identification. Ten common words used in children's books were arranged on a single sheet of paper. The children were asked to read the words and the number identified was recorded.

Receptive Vocabulary. A standardized 98-item receptive vocabulary test was used (Verhoeven, Vermeer & Van de Guchte, 1986). Each item had four picture alternatives and the child was asked to point to the picture that best represented a word spoken by the experimenter. The test ended when the child failed to select two items or more correct out of eight consecutive items. The score was the number of correctly identified items.

Phonemic Awareness. Phonemic awareness was measured using two tasks: phoneme blending and phoneme segmentation. The sum of the two tasks was used for analysis.

Phoneme Blending. Ten digitally recorded (16 bit at 22Khz) segmented words were presented aurally by means of a computer. Each segment of the word was presented at one second intervals. The stimuli contained two items in each of the following word structures, VC, CVC, CCVC, CVCC, CCVCC (note: C = consonant, V = vowel). The words used were single syllable, high-frequency words that were known by more than 95 percent of children at this age level (Kohnstamm, Schaerlaekens, de Vries, Akkerhuis, & Froonincksx, 1981). The reliability score (Cronbach's alpha) for this test was 0.88.

Phoneme Segmentation. Ten digitally recorded whole words were presented using a computer; the children were asked to verbally respond with the phoneme segments. The Cronbach's alpha test of reliability was 0.87.

Gating Task. The children were asked to identify words from partial acoustic signals presented through headphones (Metsala, 1997). In this test there were five different, high-frequency, single syllable (C)CVC(C) words known unanimously by all five- and six-year olds. These words have few or no lexical neighbors. The average length of a word was 433 ms which took 10 gates to present. The stimulus array was started at 133 ms and after each round the gate was increased by 33 ms. The test took 8 to 11 minutes to complete. The score for the test was the number of gates required to name a word correctly given that the subsequent trial was also correctly answered. In further analyses, the mean number of gates required to identify the words is used. A lower score indicates better performance, but for correlational analyses, the scores were multiplied by –1 so that high scores indicate better performance.

Cued Word Fluency. Children were asked to say, within 20 seconds, as many words as they could think of that began with a certain consonant phoneme. For example, "Say as many words that you can think of that begin with /b/." The total number of words produced was noted. The first six questions in the test were cued with single stop or continuant consonants. The final four questions in the test were cued by consonant clusters (e.g., /br/, or /sp/). The split half test of reliability was 0.80. For further analyses, the sum of correctly named words was used.

Nonword Repetition Task (NWR). In this test the children were asked to repeat as accurately as possible 15 pseudowords. The words were either two or three syllables in length. A response was considered correct if all phonemes were articulated. The absence of phonemes, syllables, or the substitution of phonemes was considered incorrect. The score for this test was the total number of correctly repeated words. The test reliability (Cronbach's alpha) was 0.62.

Tests in Grade 1. In Grade 1, the word decoding test and phonemic awareness tests were administered in a session that took about 15 minutes. The phoneme blending and phoneme segmentation tests were the same as administered in kindergarten (see above for descriptions).

Word Decoding. To measure the word decoding ability of children in Grade 1, the One-Minute-Test (OMT) of word decoding, a Dutch-normed test (Brus & Voeten, 1973) was administered. The difficulty of words ranged from single syllable words to multisyllabic words. Each word was scored correct if the child was able to read the word aloud. The score for this test was the number of correctly identified words within one minute.

ANALYSIS OF DATA

To replicate the regression analysis from Metsala's (1997) study, the following procedure was used. For the first regression, the kindergarten variables PA, written language knowledge (letter-sound knowledge and visual word identification), and vocabulary were entered in a single step. These variables represent often used predictors of language and reading problems. Any predictor that significantly accounted for variance of the dependent variable in this first step remained in the equation. Next, the three QPR tests of NWR, cued word fluency, and gating were entered in a second step, and significant predictors were noted. The resulting predictive variables were used in a sepa-

rate fixed order hierarchical regression analysis. Finally, the order of entry of variables in the latter analysis was reversed to determine the unique contribution of the variables.

RESULTS

In table I, the results of tests in kindergarten and Grade 1 are shown. Twenty eight percent of the children were unable to identify a single letter, and in total, 70 percent of the entire group identified four or fewer letters. The majority of the children were not phonemically aware (PA). The average on the vocabulary test was within the expected average based on national norms for this age group.

On the gating task, the average number of gates required for identification was 3.28 which corresponds roughly to the first 220 ms of the entire word. Some children were able to successfully identify the item with only 133 to 150 ms of acoustic information, but others needed to hear almost the entire word. The cued word fluency task was difficult; many children were unable to produce a single item. The average correct on the NWR task was high. Even so, there were a number of children who had difficulty articulating what they had just heard.

Table II shows the Pearson correlations between kindergarten variables (below the diagonal). Children with good letter sound knowledge and visual word recognition tended to have better PA, and do better on the cued word fluency. PA was significantly correlated with the nonword repetition and the cued word fluency task. Gating and nonword repetition correlated with each other. Gating correlated with the vocabulary test but nonword repetition did not.

Table I. Descriptive Statistics of Tests in Kindergarten and Grade 1.

	Test	M	SD	Range	
Kindergarten	Letter Sound Knowledge (27)*	5.24	6.78	0.0	24.0
	Visual Word Recognition (10)	0.34	1.52	0.0	8.0
	Phonemic Awareness (20)	4.45	5.74	0.0	17.0
	Nonword Repetition (15)	11.97	2.40	7.0	15.0
	Cued Word Fluency	5.76	7.65	0.0	25.0
	Gating (10)	3.28	1.38	1.4	7.8
	Vocabulary (98)	50.03	14.20	28.0	81.0
Grade 1	Phonemic Awareness (20)	17.48	3.26	8.0	20.0
	Word Decoding (116)	13.79	6.21	4.0	27.0

* Number in parentheses refers to number of items in test.

Table II. Kindergarten and Grade 1 Correlations.

Variables	1	2	3	4	5	6	7	8	9
Kindergarten (1-7)									
1. Letter Sound Knowledge	–								
2. Visual Word Identification	.57**	–							
3. Phonemic Awareness	.65**	.35*	–	.38*	.82**	.16	.13	.27	.23
4. Nonword Repetition	.42*	.27	.54**	–	.25	.39*	.07	.52**	.14
5. Cued Word Fluency	.65**	.48**	.88**	.45*	–	.13	.27	.33	.29
6. Gating	.17	.05	.24	.41*	.20	–	.44*	.51**	.47*
7. Vocabulary	.06	-.09	.14	.08	.22	.44*	–	.23	.07
Grade 1 (8-9)									
8. Phonemic Awareness	.35	.18	.42*	.59**	.46*	.53**	.24	–	.20
9. Decoding	.38*	.19	.44*	.34	.50**	.54**	.17	.46*	–

$^{*}p < 0.05$, $^{**}p < 0.01$

Note: Pearson's correlation coefficients are below the diagonal and partial correlations above the diagonal with variance attributable to letter knowledge partialed out.

Table III. Hierarchical Regression Analyses Predicting Decoding Scores in Grade 1.

Predicted variable	Step		Variable	Change in R^2	Total R^2	F
First Regression Analysis:						
Grade 1 Word Decoding	I	1.	PA (Kindergarten)	.20	.20	6.75
		2.	Gating	.20	.40	8.57
	II	1.	Gating	.29	.29	10.96
		2.	PA (kindergarten)	.11	.40	8.57
Second Regression Analysis:						
Grade 1 Word Decoding		1.	Age	.05	.05	1.41
		2.	Vocabulary	.04	.09	1.22
		3.	Phonological Awareness	.16	.24	2.58
		4.	Gating	.21	.45	4.96

As stated earlier, reading and letter-sound knowledge have profound effects on the development of PA. To examine the variables in the absence of literacy knowledge, we calculated partial correlations and controlled for the shared variance of kindergarten visual word recognition and letter-sound knowl-

edge. The results are presented above the diagonal in table II in italics. PA continued to be significantly correlated to cued word fluency and to nonword repetition. The gating task correlated both with nonword repetition (0.39) and with vocabulary (0.44).

In Grade 1, the average on PA tasks approached ceiling level (table I). The mean score on the standardized word decoding test was almost 14, slightly above the average expected for this age group. In table II, correlations between kindergarten and Grade 1 variables are presented (see variables 8 & 9). Knowledge of letter sounds in kindergarten correlated significantly with decoding ability in Grade 1. PA in kindergarten correlated significantly with PA and word decoding in Grade 1. Nonword repetition, cued word fluency, and gating all correlated significantly with Grade 1 PA; the strongest coefficient was between nonword repetition and PA, $r = .59$. Of the three QPR tasks, only cued word fluency, and gating correlated with Grade 1 word decoding. The partial correlations between kindergarten variables and decoding show that nonword repetition and gating were the only kindergarten variables that correlated significantly with Grade 1 PA. For word decoding, only the gating task was significantly correlated after removing the shared variance with early literacy skills.

The results of the first regression analysis (see table III) revealed that kindergarten phonemic awareness accounted for 20 percent with gating accounting for an extra 20 percent. In the reverse order analysis, the gating task predicted 29 percent of variance in Grade 1 word decoding with an extra 11 percent taken up by phonemic awareness.

In the second regression analysis (see table 3), we replicated the analysis reported in Metsala (1997). Metsala found, in a crosssectional design, that gating of words from sparse neighborhoods was a significant predictor of reading ability after accounting for the contributions of age, vocabulary, and PA. In the present analysis, we replicated this by using similar variables to predict variance in Grade 1 word decoding. Age, kindergarten vocabulary knowledge, and kindergarten PA scores accounted for a total $R^2 = 0.24$ with PA accounting for 16 percent after entering age and vocabulary. The results also show that performance on the gating task in kindergarten accounted for an extra 21 percent of the variance in word decoding scores in Grade 1. Gating uniquely accounted for a considerable amount of variance, even when PA had been entered.

DISCUSSION

The first study examined if nonword repetition, gated auditory word recognition, and cued word fluency could be used to measure differences in QPR in preschoolers. The results suggest that gating and NWR measure differences in QPR. The second goal was to examine if individual differences in the various tasks administered in kindergarten predicted variance in Grade 1 PA and reading skill. The results show that a sizeable amount of the variance in reading ability can be attributed to individual differences in kindergarten PA, and a unique proportion of the variance is accounted for by individual differences on the gating task in kindergarten.

Cued word fluency correlated with concurrent PA and with Grade 1 PA, which suggests that cued word fluency may be considered as a measure of PA in kindergarten. However, due to the strong correlation found with kindergarten literacy skills, the cued word fluency does not adhere to our requirements for a test of QPR.

Interestingly, in the current study, we found no relationship between nonword repetition and vocabulary (r = 0.08). This finding is inconsistent with Gathercole and Baddeley (1997). Perhaps the test in our study is not sufficiently reliable and could perhaps be improved by presenting the stimulus items in a prerecorded fashion, reducing variability in presentation as suggested by Gathercole and Baddeley (1997).

In the present study, we replicated part of Metsala's (1997) study in which she found that the scores on a gating task accounted for a significant amount of unique variance in word reading scores in 30 normal achieving eight-year-old readers. We used the gating task in the present study to predict Grade 1 PA and reading skill development based on measures gathered during kindergarten. The individual differences in scores on the gating task correlated both with nonword repetition and with vocabulary in kindergarten, and the gating task also appeared as a predictor of PA and word decoding skill in Grade 1. Grade 1 word decoding was predicted to a greater extent by variance on the gating task than by kindergarten PA, the only other significant variable.

The results with the gating task clearly confirm the previous findings of Metsala (1997). The current study, however, adds to Metsala's (1997) study in that a longitudinal design was used to evaluate the predictive power of the gating paradigm. Of course, the sample is relatively small (n = 29), and it is known that multiple regression analyses may be unstable in small samples.

The present study provides evidence that QPR plays a significant role in the development of PA and reading acquisition. The findings also suggest that tests can be created to measure reliably individual differences in QPR of kindergarten children. However, due to the small sample size, a larger replication is required to confirm findings. A replication study also would provide data regarding the reliability and stability of QPR in kindergarten.

STUDY 2

The first study presented positive evidence that individual differences in the quality of phonological representations measured in kindergarten are predictive of Grade 1 PA and reading ability. The purpose of the second study was to replicate the previous findings.

The two specific questions remain the same as in the original study. Is it possible to measure differences reliably in the quality of phonological representations? Second, are individual differences in the quality of phonological representations related to the development of Grade 1 PA and reading skills?

METHOD

Participants. Sixty-two second year kindergarten children participated. Their mean age was 6 years and 1 months (SD = 4 months). The first moment of testing was three months before the end of the school year and the posttest, five months into the new school year. The children came from six different classes spread over two schools. Each class had a mixture of first year and second year kindergarten children; only the second year kindergarten children participated. Approximately 45 percent of the children came from Dutch families. The remainder came from Turkish, Moroccan, or Surinam families. Only those children that spoke Dutch as their first language participated.

TASKS AND PROCEDURE

Pretests in Kindergarten Eight different tests were first administered to the children in kindergarten in one session taking approximately 35 minutes. The following tasks remained unchanged from those used in the first study: letter and word identification, passive vocabulary knowledge, cued word fluency, phoneme blending, and phoneme segmentation. The phoneme blending, and segmentation were combined into a single PA variable for analysis purposes.

Gating Task. For the gating task, the number of items was increased from five to six. In order to keep the amount of time required for testing down, the first presentation was set at 150ms and the rest of the word was divided into even sections so that on the eighth trial, the entire word would be heard. The average step size was 40ms. Instead of using the isolation point, we scored the number of times a word was correctly identified. This provides a maximum score of 8, so that if a child identified the word at 230ms, and continued to identify it correctly for the rest of the trials, the score for that item would be six. The result of a Cronbach's alpha for reliability was 0.68.

Nonword Repetition (NWR). The number of items in this test was increased to 25. The items included two one-syllable words, 7 two-syllable, 13 three-syllable, and 3 four-syllable words. The final score was the total number of correctly repeated words. The test reliability (Cronbach's alpha) was 0.70.

Posttest in Grade 1. The phoneme blending and segmentation tests from the pretest were readministered. The first test of word decoding was the One-Minute-Test (OMT) of word decoding also used in the first study. The second test of decoding was a one-minute test of decoding that only contained CVC words. For analysis, word decoding was the average of the two tests of reading.

RESULTS

In table IV, the pre- and posttest results for the children are presented. On average, the children recognized nine letters in the pretest, but 50 percent of the group recognized less than five letters. The two phoneme awareness tasks show that many children were insensitive to the phonological structure of language; 23 percent scored zero. The average on the nonword repetition test was 20, but some children scored as low as 14. The average on the gating task was 4.5 responses correct, approximately 280 milliseconds. The vocabulary test indicated that the average and the spread of scores were within expected norms.

The kindergarten group was retested in Grade 1. The correlations between the various tests are presented table V. Noticeable is that letter knowledge was related to almost all other kindergarten tests. Children with letter skills tended to be phonologically aware and had greater vocabulary knowledge. However, after literacy knowledge was partialled out, many of the correlations disappeared.

Table IV. Descriptive Statistics of Tests in Kindergarten and Grade 1.

$N = 62$	Test	M	SD	Range	
Pretest	Letter Sound Knowledge (27)*	9.05	8.09	0.0	24.0
Kindergarten	Visual Word Recognition (10)	0.94	1.92	0.0	7.0
	Phoneme Awareness (20)	3.94	4.91	0.0	18.0
	Nonword Repetition (25)	19.98	2.80	14.0	25.0
	Cued Word Fluency	2.34	3.13	0.0	12.0
	Gating (8)	4.57	0.76	2.5	6.0
	Vocabulary (98)	54.24	16.88	21.0	90.0
Posttest	Phoneme Awareness (20)	16.73	3.79	2.0	20.0
Grade 1	Word Decoding	17.54	10.80	0.0	60.0

* Number in parentheses indicates number of items in test.

Table V. Pre- and Postest Correlations.

Variables	1	2	3	4	5	6	7	8	9
Pretest Kindergarten (1-7)									
1. Letter Sound Knowledge	–								
2. Visual Word Identification	.65***	–							
3. Phonemic Awareness	.48***	.70***	–	.35***	.46***	.29**	.36***	.25**	–.21
4. Nonword Repetition	.06	.25**	.41***	–	.13	.03	.12	.35**	.00
5. Cued Word Fluency	.52***	.48***	.61***	.17	–	–.04	.16	.03	–.23
6. Gating	.23*	.21	.35**	.06	.10	–	.25*	-.01	–.15
7. Vocabulary	.27**	.31**	.46***	.17	.30*	.31*	–	.22	–.11
Posttest Grade 1 (8–9)									
8. Phonemic Awareness	.39***	.23	.34**	.32**	.22	.07	.29**	–	.30**
9. Word Decoding	.64***	.46***	.23	.06	.19	.04	.10	.46***	–

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Pearson's correlation coefficients appear below the diagonal. Partial correlations, with variance from letter and word knowledge removed, are printed above the diagonal.

In Grade 1, PA and word decoding showed relatively high correlation coefficients. However, PA scores in kindergarten were only weakly correlated with Grade 1 word decoding scores ($r = .23$, $p < 0.10$). The strongest correlation between

kindergarten variables and Grade 1 word decoding was with kindergarten letter knowledge ($r = 0.64$, $p < 0.01$).

In the first study, kindergarten NWR ability correlated with Grade 1 PA, and in the current study, a similar correlation was found between NWR and grade 1 PA. In the first study, gating and cued word fluency were both correlated with Grade 1 PA ($r = .53$ and $r = .46$, respectively). In the present study, these relations were absent. Neither gating nor cued word fluency were correlated with Grade 1 word decoding.

A hierarchical regression analysis was performed to determine the predictability of Grade 1 word decoding from kindergarten variables. Only kindergarten letter knowledge accounted for significant variance in Grade 1 word decoding ($R^2 = .41$). Replicating Metsala's (1997) regression analysis (see table III) produced no significant predictors of Grade 1 word decoding.

DISCUSSION

Findings from Study 2 did not confirm the conclusions from the first study. The QPR measure did not have a direct relationship to Grade 1 PA or word decoding. Although NWR was related to Grade 1 PA, no relationship was found between Grade 1 PA and either gating or the cued word fluency task. Unlike the first study, in the second study, gating was not a predictor of either Grade 1 PA or word decoding. It is possible that the relatively higher letter-sound knowledge of the kindergarten children confounded performance on the gating task. However, recalculating the correlations by only including children who had no letter-sound knowledge did not significantly alter the correlational patterns.

Taken together, the results of the first two studies to predict PA and word decoding based on individual differences in the quality of phonological representations present some interesting problems. Although in both studies cued word fluency, nonword repetition, and gating were related to phonological skills in kindergarten children and Grade 1 children, the pattern of correlations reported in the two studies was not stable. Correlations found in the first study were not replicated in the present study. Although the internal stability of the tests was found to be reasonable, it is possible that the differences may have been due to the reliability of the measures over time. The variability in children's ability and experiences prior to Grade 1 appears to be greater than after formal schooling begins. It is possible that some of the differences found between Studies 1 and 2 were attributable to the scale of variability in kindergarten childrens' ability.

STUDY 3

The first two studies revealed somewhat contradictory results. The findings suggest that measures of the quality of phonological representations can predict and account for individual differences in Grade 1 PA and reading acquisition. However, relationships between QPR, PA, and reading acquisition varied. We propose that these discrepancies may be due in part to individual differences in growth curves in preschool development of language and phonological representations (Vihman, 1993).

To gain some insight into the stability of the QPR tasks, we conducted a third study in which predictors from both the first and second year of kindergarten were used. The goals of this study were to replicate and expand the procedure of the previous two studies by examining if QPR in first and second year kindergarten can predict Grade 1 reading acquisition and phoneme awareness. A second aim was to examine the stability of reading skills, including word identification and letter knowledge, and the development of phonological awareness from the first year of kindergarten until Grade 1.

METHOD

Participants. Forty-two first year kindergarten children participated with a mean chronological age of 5 years and 1 months (SD = 5 months). The first moment of testing (T1) was 3 months before the end of the children's first school year; the second test moment (T2) was 4 months before their second kindergarten year, and the posttest, 6 months into Grade 1 (T3). Approximately 55 percent of the children were from Dutch descent while the other 45 percent were mainly Turkish, Moroccan, or from Surinam. Only those children that spoke Dutch as their first language participated.

MATERIALS AND PROCEDURE

Pretests in Kindergarten (T1 and T2). Eight different tests were first administered to the children in kindergarten in two sessions, taking a total of about 35 minutes for both. The tasks remained unchanged from those used in Study 2.

Posttest in Grade 1 (T3). The PA, NWR, cued word fluency, and vocabulary test from the pretest (T1 & T2) were readministered. Two word decoding tests were administered: the OMT and a CVC word decoding task (see Study 2). For analysis, letter and word reading scores were combined as a literacy variable.

RESULTS

In table VI, the descriptive statistics for all three test moments are presented. At T1, the kindergarten children had little or no effective knowledge of reading or letters, and 52 percent had no knowledge of letters and words. The PA tasks were difficult. Fifty-seven percent of the children were unable to complete a single item. Of the three QPR tasks, cued word fluency suffered from floor effects. Nonword repetition and the gating task appeared to be attempted adequately by all children at T1.

At T2, more children were able to name or sound out at least one letter; only 16 percent still scored zero. Tasks requiring phonemic awareness continued to present great difficulty. On the phonological awareness tasks, 26 percent scored zero. The average scores on cued word fluency, NWR, and the gating tasks increased over those a year earlier. The vocabulary score also increased and was within the expected norms (Verhoeven, Vermeer, & Van de Guchte, 1986).

In Grade 1, the children were reading 22 words per minute on average and had mastered most of the letters. In table VII, correlations are presented for the various tests for all three test

Table VI. Descriptive Statistics of Three Testing Periods (T1, T2 & T3).

N = 42	Test	M	SD	Range	
T1	Literacy	2.14	2.91	0.0	10.0
Kindergarten	PA	0.98	1.57	0.0	7.0
	Nonword Repetition (25)	17.60	2.87	10.0	22.0
	Cued Word Fluency	0.40	0.80	0.0	3.0
	Gating (8)	3.94	0.83	2.3	5.3
	Vocabulary (98)	40.60	17.15	12.0	80.0
T2	Literacy	5.32	4.31	0.0	16.0
Kindergarten	PA	3.05	4.38	0.0	20.0
	Nonword Repetition (25)	20.73	3.47	12.0	25.0
	Cued Word Fluency	3.53	3.96	0.0	17.0
	Gating (8)	4.15	0.97	1.5	5.8
	Vocabulary (98)	51.73	16.78	25.0	84.0
T3	Literacy	34.08	20.24	1.0	85.0
Grade 1	PA	15.38	3.33	6.0	20.0
	Nonword Repetition (25)	17.52	3.13	12.0	24.0
	Cued Word Fluency	13.45	6.11	3.0	31.0
	Vocabulary (98)	69.48	16.21	39.0	92.0

* Number in parentheses indicates number of items in test.

Table VII. Pearson's Correlations for all Variables at T1, T2 and T3.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Kindergarten T1 (1-6)																
1. Literacy																
2. PA	.17															
3. Nonword Repetition	.08	.18														
4. Cued Word Fluency	.08	.14	.12													
5. Gating	–.15	.07	.44**	.17												
6. Vocabulary	.18	-.01	.36*	.45**	.02											
Kindergarten T2 (7-12)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
7. Literacy	.60**	–.30	–.29	–.17	–.22	–.05										
8. PA	.01	.17	.30	.12	.02	.15	–.03									
9. Nonword Repetition	.28	.20	.39*	.15	.13	.29	.01	.20								
10. Cued Word Fluency	.26	.41*	.08	.05	.06	.03	.23	.21	.39*							
11. Gating	.11	.08	.12	–.06	.10	.25	.07	.06	–.12	–.06						
12. Vocabulary	.36*	–.03	.45**	.20	.02	.78**	.00	.22	.24	.11	.29					
Grade 1 T3 (13-17)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
13. Literacy	.03	–.02	.05	–.16	–.05	–.01	.27	.24	.34	.30	–.32	.07				
14. PA	.11	.11	.38*	–.08	.21	.34*	.08	.30	.61**	.21	–.03	.48**	.54**			
15. Nonword Repetition	.05	.09	.27	.00	.03	.29	–.07	.15	.38*	.06	–.17	.33*	.18	.43**		
16. Cued Word Fluency	–.06	.15	.21	.22	.22	.35*	.01	.24	.39*	.45**	–.12	.33*	.61**	.61**	.45**	
17. Vocabulary	.26	–.03	.20	.17	–.01	.76**	.12	.09	.39*	-.04	.32	.77**	.01	.51**	.35*	.25

* $p < 0.05$, ** $p < 0.01$

periods. At T1, nonword repetition was correlated to the gating task and vocabulary knowledge. The relationship between NWR and vocabulary was not found in either of the previous two studies even though the tasks were the same.

Some tasks at T1 correlated to tasks at T2. Literacy knowledge correlated to the same variables at T2. Phonemic awareness at T1 correlated to cued word fluency a year later. Nonword repetition correlated to the same task a year later and also at T3. The vocabulary scores at T1 had strong correlations to vocabulary T2 and T3.

There were a number of significant correlations between tasks at T2 and T3. Nonword repetition at T2 had strong correlations to a number of tasks at T3. The strong correlation between nonword repetition in preschool and Grade 1 phonemic awareness also was reported in the first two studies. Vocabulary at T2 correlated with PA, nonword repetition, cued word fluency, and vocabulary at T3.

The correlation analysis provided some information about the predictability of Grade 1 scores. Tasks administered at T1 had very little predictive ability for Grade 1 test scores. Only Grade 1 PA was predictable to some extent in the first year of kindergarten T1 measures of NWR and vocabulary. A regression analysis with all first year variables, including age, revealed that NWR was the single most significant predictor of grade 1 PA ($R^2 = .14$, $F = 6.71$, $p < 0.05$).

Measures taken at T2 were more predictive of T3 scores than ability at T1. Phoneme awareness in Grade 1 was accounted for by T2 NWR and vocabulary ($R^2 = .49$, $F = 16.12$, $p < 0.01$). NWR predicted an extra 26 percent of the variance in T3 PA after vocabulary at T2 had been entered, $\Delta R^2 = .26$. Entering T2 NWR first ($R^2 = .37$) and then T2 vocabulary knowledge resulted in $\Delta R^2 = .12$. Forcing T2 PA into the regression accounted for 11 percent of variance of PA at T3.

Reading ability in Grade 1 was difficult to predict from kindergarten measures. From all T2 variables, NWR was the single most significant predictor of literacy ($R^2 = .11$, $F_{(40)} = 4.22$, $p < 0.01$). To examine if reading ability could be partially accounted for by early QPR, we conducted a multivariate regression analysis with Grade 1 literacy as the dependent variable. First, we entered T2 literacy ($R^2 = 0.07$). In step 2, T2 NWR was entered ($\Delta R^2 = 0.12$). In step 3, PA from T3 was entered into the regression ($\Delta R^2 = 0.24$). We then reversed the order of steps 2 and 3, putting PA ($\Delta R^2 = 0.36$) before NWR ($\Delta R^2 = 0.00$). The variance shared between NWR and Literacy at T3 was entirely taken up by PA at T3.

DISCUSSION

In the final study, results of a two-year longitudinal study were presented in which the development of reading skills, phoneme awareness, vocabulary, and QPR were followed from the first kindergarten year until Grade 1. One goal was to examine if measures of QPR predict Grade 1 reading acquisition and PA development. A second aim was to ascertain if preschool abilities are stable from the first to the second year of kindergarten.

The results of the final study confirmed that Grade 1 ability in reading and phonological awareness could be predicted in kindergarten children on the basis of measures of nonword repetition, PA, and vocabulary knowledge. Prediction of Grade 1 PA was successful and accounted for 49 percent of the variance in phonemic awareness. Reading ability was harder to predict: NWR accounted for 11 percent of variance. However, the variance shared between NWR and literacy was a subset of the variance share between Grade 1 PA and literacy. This finding illustrates how QPR is important for development of PA that, in turn, is crucial for literacy development.

In the discussion of Study 2, the possibility was raised that individual differences in the developmental experiences of preschoolers would cause an uneven and discontinuous advancement in cognitive abilities that would manifest itself in lower test-retest correlations between measures taken in kindergarten. From the first to the second year of kindergarten, only the literacy and vocabulary scores showed a reasonably high correlation. PA in kindergarten did not correlate with PA in the second year of kindergarten. Of the QPR tests, only NWR correlated between the first and second year of kindergarten. The auditory gated word recognition task was an inconsistent predictor of Grade 1 PA and reading acquisition. The gating task was also unreliable in the test-retest situation, as no correlation was found between gating at T1 and T2. At the time of writing, no information regarding test-retest reliability of the gating task was available in the literature for kindergarten children and so this finding presents an interesting topic for further investigation. The results suggest that abilities like PA and QPR may not develop in a continuous gradual slope and, instead, may be subject to spurts of rapid advancement. If this is the case, then caution must be taken when conducting prediction studies using kindergarten children. One possibility to reduce the effect of this variability would be to use multiple measures of cognitive constructs within a few weeks of each other.

GENERAL DISCUSSION

As stated earlier, the reciprocal relationship of PA and reading development makes it difficult to use tests of explicit PA in kindergarten to predict Grade 1 reading difficulties. The findings of our three studies show that there are alternatives to the traditional phoneme blending and segmentations tasks that can be used to provide reasonable predictive potency. The nonword repetition task proved to be a consistent predictor of both concurrent and later phonemic awareness. Cued word fluency was effective as a measure of early phonemic awareness development as it was found to be a consistent correlate of concurrent PA. In the third study, cued word fluency correlated with Grade 1 cued word fluency, and in the same study, Grade 1 cued word fluency was strongly correlated with concurrent reading ability, PA, and NWR. The results of the cued word fluency task suggest that it warrants further investigation as a reasonably intuitive PA test for use with kindergarten children.

The results of Study 3 revealed that some tasks had low test-retest reliability. However, tasks such as vocabulary knowledge showed high test-retest correlations. Phonological awareness, word reading, and letter knowledge were very difficult for kindergarten children and exhibited floor effects at T1. The restriction of range was undoubtedly a big contributor to the low correlations. One explanation for the low QPR test-retest correlations between first and second kindergarten year could be that auditory word perception increases in qualitative spurts rather than gradually. The variation in development between subjects would then result in low correlations between test moments. Nevertheless, the gating task used in the current study was inconsistent and therefore possibly not suitable to use as a measure of QPR. Unlike the other QPR tasks, the nonword repetition task did have good test-retest correlation from T1 to T2. Kindergarten scores on the nonword repetition task consistently correlated to development of PA, better than kindergarten measures of PA.

The QPR tests, NWR, and gating resulted in a very different pattern of correlations. It is possible that the difference between the NWR task and the gating was due to the procedure. Repeating nonwords is a more "natural" task for preschoolers than listening to barely identifiable sounds played through headphones attached to a computer. Also, repeating nonwords requires not just perceptual ability but also retention (working memory) and articulation, all characteristics of a good lexical system. It would be interesting to narrow down what factor(s) in

the nonword repetition task accounted for the variance in PA development. Recent work by Oakhill and Kyle (1999) suggests that working memory does not account for significant independent variance in performance on measures of phonological awareness(see also Dufva, Niemi, & Voeten, 2001). This leaves auditory perception and articulation as possible contributors to PA development. There is some evidence for both perception and pronunciation. In a study by Post, Foorman, and Hiscock (1997), skilled Grade 2 and 3 readers were compared to less-skilled readers on a speech perception and production task. No significant differences were found on the production of two-syllable words, but the less-skilled readers were significantly less accurate on a vowel identification task. Their conclusion was that vowel phonemes are less securely represented in the perceptual system of less-skilled readers and that selective perceptual impairment underlies some of the phonological awareness problems associated with poor reading ability.

Impairment in articulation has also been found in a study by Das, Mishra, and Kirby (1994) who reported on two cognitive tasks that differentiated between dyslexics and nondyslexics. These tasks required perception of phonological information and also rapid articulation, that is, arguably requirements of a nonword repetition task. Elbro, Borstrøm, and Petersen (1998) found that individual differences in preschool children's ability to accurately pronounce words uniquely predicted PA in Grade 2. The findings of our three studies confirm the potential of nonword repetition as a good predictor of PA development and support the findings reported above.

In Studies 1 and 2, no relationship was found between passive vocabulary knowledge and nonword repetition which is typically reported in the research literature. The finding of no relationship between nonword repetition and vocabulary is not without precedent. Edwards and Lahey (1998) reported that nonword repetition was only related to expressive and not to passive measures of vocabulary (as used in our studies). In our studies, nonword repetition was the most potent predictor of Grade 1 PA. Thus, it could be argued that an important component of the current nonword repetition test is related to the ability to form transient phonological representations in verbal short-term memory and to assemble articulatory instructions. Although no relationship with vocabulary was obtained, the results suggest that a nonword repetition test may be a sensitive measure of a latent phonological processing factor (Bowey, 1996) involved in processing segments of speech.

Typically, reading skills can be predicted, in part, by preschool phonemic awareness. The correlation coefficient between kindergarten PA with Grade 1 reading skills was lower than that found in a similar, well-known, study by Wagner, Torgesen, and Rashotte (1994). In their study with 288 American school children, correlations between kindergarten phoneme awareness, phoneme synthesis, and Grade 1 word decoding were $r = 0.82$ and $r = 0.59$, respectively. The magnitude of correlation coefficient differences between their study and the present study may lie in a number of areas. Wagner et al. (1994) used a latent variable design to predict Grade 1 reading. The latent variable was composed of tasks that may have tapped a greater amount of variance in kindergarten phonological skills. Alternatively, it has been argued that early phonological skills are more important for reading acquisition in English than in Dutch. English has a deep orthography, whereas Dutch has a more regular correspondence between graphemes and phonemes.

The teaching of reading in American schools and schools in the Netherlands also may have an effect on the relative importance of phonological skills for reading acquisition. Bast and Reitsma (1998) and De Jong and Van der Leij (1999) reported that the effect of PA on early reading acquisition in Dutch children was limited, possibly due to extensive use of phonics teaching methods employed in the Netherlands. Wesseling and Reitsma (1998) reported that children not phonologically aware at the end of kindergarten did not lag behind peers on tests of phonological skills five months after starting Grade 1. We suggest that differences in the scale of the correlations in the present study and that of Wagner, Torgesen, and Rashotte (1994) may be attributable to differences in language and/or teaching methods.

Measuring and testing the parameters of the theoretical quality of phonological representations have proved to be reasonably complex. The literature on phonological representations and reading development uses terms such as diffuse, incomplete, impoverished, and indistinct to describe how representations differ between normal and dyslexic children (Elbro, Nielsen, & Petersen, 1994; Fowler, 1991; Metsala, 1997). The manner in which phonological representations are related to lexical items is often referred to in a global manner and the exact relationship between the two is mostly left unspecified.

The results of our three studies provide inconclusive support for the theory that individual differences in the quality of

phonological representations play an important role in the development of PA and, at least indirectly, to reading acquisition. The results of the present studies do confirm that individual differences in language skills, nonword repetition, and PA are important factors in predicting the development of reading related skills, but how the underlying quality of phonological representations is causally related to the development of phonemic awareness and reading problems has remained elusive. One important outcome has been to demonstrate that caution needs to be maintained in measuring skills in preschoolers as stability of results can be an issue when interpreting the relations between variables.

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